ONTARIO GEOLOGICAL SURVEY

Open File Report 5562

Aggregate Resources Inventory of Hallam, McKinnon, Mongowin and Foster Townships, District of Sudbury, and Shedden Township, District of Algoma

1985

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Northern Affairs
and Mines

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Aggregate Resources Inventory of Hallam, McKinnon, Mongowin and Foster Townships, District of Sudbury, and Shedden Township, District of Algoma

by

Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey

1985

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V.G. Milne

V.G. Milne, Director
Ontario Geological Survey

FOREWORD

Hallam, McKinnon, Mongowin, and Foster Townships, District of Sudbury, and Shedden Township, District of Algoma, contain a number of sand and gravel deposits which were laid down during glacial times. This report and its accompanying maps delineate these deposits and provide additional information regarding their thickness, geological character and suitability for use as construction aggregate. The report also indicates which deposits possess the greatest potential for resource utilization and discusses bedrock resource potential.

This report supplies valuable information which will be beneficial in resource planning.

V.G. Milne, Director
Ontario Geological Survey

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ABSTRACT

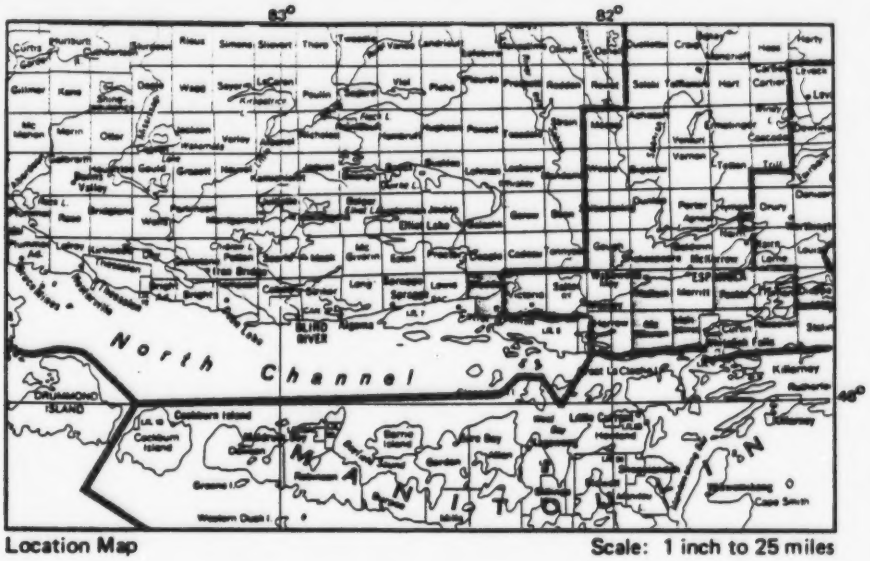

Figure 1 - Key Map Showing Location of Hallam, McKinnon, Mongowin, and Foster Townships, District of Sudbury, and Shedden Township, District of Algoma. Scale 1: 1 584 000.

This report presents the results of a sand and gravel inventory in five townships near the north shore of Lake Huron in the Districts of Sudbury and Algoma. Seven Resource Areas of Primary Significance have been selected for possible resource protection. These areas are considered the best suited for extractive development within the report area. The seven Primary Resource Areas occupy a total of 670 acres (270 ha) currently available for extraction and contain granular resources of approximately 37 million tons (34 million tonnes). In addition, several deposits have been selected for possible resource protection at the secondary level of significance. Although significant sand and gravel resources have been identified in McKinnon Township and the southern parts of Mongowin and Shedden Townships, only limited resources exist in the remaining parts of the report area. Care should be taken to ensure the continued availability of as much of the remaining resources as possible.

An alternative source of aggregate in the study area is bedrock-derived aggregate. The bedrock consists of a complex array of metasedimentary and intrusive rocks, of which Nippissing diabase is considered the best suited for possible extractive development.

Selected Resource Areas are not intended to be permanent, single land use units. They represent areas in which a major resource is known to exist and may be reserved wholly or partially for extractive development and/or resource protection.

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AGGREGATE RESOURCES OF HALLAM, McKINNON, MONGOWIN AND FOSTER TOWNSHIPS, DISTRICT OF SUDBURY, AND SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA[1]

INTRODUCTION

The sand and gravel resources of Hallam, McKinnon, Mongowin, and Foster Townships, District of Sudbury, and Shedden Township, District of Algoma were investigated by a two-man field party in the summer of 1984. This report presents the results of this study. Although the results of this work would normally be released in an Aggregate Resources Inventory Paper, the Open File Report format is used here in order to make this information available as quickly as possible. The purpose and methodology used to prepare this report are essentially the same as is used for an Aggregate Resources Inventory Paper, and are presented in Appendix A. The format in which the information is presented on the maps is explained on the map legends and in the appendices.

Granular deposits related to glacial activity are widespread in these five townships. The Primary Resource Areas outlined later in the text include the deposits which are considered the best suited for extractive development. Because a wide range of aggregate products are capable of being produced from these deposits, the continued availability of these deposits is important. It is also important that planning strategies recognize the value of these areas in land use plans.

[1] This project was jointly funded by Espanola District, Northeastern Region, Ontario Ministry of Natural Resources, and the Ontario Geological Survey, Ontario Ministry of Northern Affairs and Mines.

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The Aggregate Assessment Office of the Engineering and Terrain Geology Section, Ontario Geological Survey, previously prepared an inventory of the aggregate resources in Nairn, Baldwin and Merritt Townships located just north of the eastern part of the report area (Ontario Geological Survey 1983).

LOCATION AND POPULATION

The report area includes Hallam, McKinnon, Mongowin, and Foster Townships, District of Sudbury, and Shedden Township, District of Algoma, which are located near the north shore of Lake Huron. Hallam, McKinnon, Mongowin and Foster Townships surround Merritt Township in which the Town of Espanola is situated. These townships lie within the southwestern part of the District of Sudbury. Shedden Township is located approximately 45 km west of the Town of Espanola in the southeastern part of the District of Algoma. The study area embraces approximately 108,400 acres (43 870 ha) and is covered by the Espanola (41 I/5), Spanish (41 J/1), Whiskey Lake (41 J/8) and Whitefish Falls (41 I/4) map sheets of the National Topographic System, at a scale of 1:50 000.

Hallam Township is part of the Spanish River Township Municipality. The Town of Webbwood is the major population centre in Hallam Township and, in 1982, Webbwood had a population of 513 (Ontario Ministry of Municipal Affairs and Housing 1984). In the unorganized townships of McKinnon, Mongowin and Foster, the population is sparse. The population of Shedden Township which is included in the North Shore Township Municipality is concentrated in the community of Spanish.

Economic activity in the area is largely related to the forest industry and tourism. Several areas within the townships have recently been logged, and a pulp and paper mill and a sawmill operation are located nearby at Espanola and Nairn Centre, respectively. Major recreation areas include the North Channel of Lake Huron, especially the Bay of Islands areas south of Mongowin Township. Access to the North Channel is provided at Whitefish Falls along the southeastern border of Mongowin Township and in Shedden Township at the mouth of the Spanish River. A major cottage area is in the process of development along the shore of Lake Huron in Mongowin Township. Cottages have also been

developed on several inland lakes within the area. A number of farms exist within the report area and are especially numerous in Hallam Township.

Access to the area is provided by King's Highway 17 which runs east-west across Hallam and Shedden Townships, and King's Highway 6 which runs south from Espanola to Manitoulin Island. Several gravel-surfaced roads branch off these highways. Rail service is provided by the Canadian Pacific Railway which has tracks paralleling Highways 17 and 6.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The glacial deposits in the report area are underlain by Precambrian bedrock, which also occurs at the ground surface throughout much of the report area. The bedrock consists of a complex array of metasedimentary and intrusive rocks. The nature of these rocks has been described in detail by Card (1968; 1976; 1978; 1984), Card et al. (1977), Robertson (1977), Robertson and Siemiatkowska (1971) and Robertson et al. (1972). For further information on the bedrock geology of the area, the reader is referred to these reports. The bedrock is primarily responsible for the 'rock knob' and 'rock ridge' physiography of the report area (Gartner 1980; VanDine 1980). This topography is largely caused by differential weathering between the various rock types, as well as by erosion by the ice sheet as it moved over the area. The most prominent bedrock feature in the report area is the La Cloche Mountains along the shore of Lake Huron in McKinnon and Mongowin Townships. These resistant ridges of white quartzite generally rise between 300 and 500 feet (91 and 152 m) above the surrounding terrain.

Glacial and postglacial materials make up the remainder of the land surface. These deposits are related to the last major advance and withdrawal of a continental ice sheet during the Late

Wisconsinan Substage of the Pleistocene Epoch. Till is the oldest surficial sediment in the report area and was deposited as ice advanced to the southwest. The till generally occurs as a thin veneer over bedrock (Boissonneau 1968). Till is generally not well suited for aggregate use as it often contains excess fines and abundant oversize clasts. In places it may be acceptable for use as fill.

Several deposits of ice-contact stratified drift were deposited in close proximity to the ice front as it retreated northward. Most of these deposits occur as small patches of sand and gravel flanking the south side of rock knobs. However, a number of these deposits are of sufficient size to be considered important aggregate sources in the report area.

The outwash features in the study area were deposited by meltwaters flowing in bedrock depressions beyond the ice margin towards the Lake Huron basin. The outwash associated with the Spanish and Serpent River valleys, which acted as meltwater channels, consists predominantly of fine to medium sand. The outwash deposited at the community of Spanish consists of coarser material and is believed to have been deposited in close proximity to the ice front. Several pits have been opened in outwash deposits within the project area.

As the ice front continued its retreat, meltwaters occupying a proglacial lake in the Lake Huron basin inundated the area. Glaciolacustrine features in the report area include lacustrine plain and beach deposits as well as a delta. The delta was deposited in southern McKinnon Township by meltwaters flowing into the glacial lake as ice occupied a position along the La Cloche Mountains. The deltaic sand and gravel appears well suited for possible extractive development. Glaciolacustrine plain sediments consisting of fine sand, silt and clay were deposited in areas of lower elevation throughout the report area. The silt and clay was

deposited in the deeper waters of the lake and in places overlies ice-contact and outwash deposits. The fine sand which was deposited in shallow areas of the lake has been extracted for low-specification borrow material near the Town of Webbwood. Along the Spanish River these nearshore sands were observed overlying lacustrine deep water sediments. As the lake levels lowered, shoreline wave action resulted in lacustrine beaches being developed. Beach sand and gravel was deposited near the shore of Lake Huron along the base of prominent bedrock ridges and on the surface of deltaic, ice-contact and outwash deposits. Several of these beach deposits are well suited for extractive development.

In the period since the disappearance of the ice sheet and the lowering of lake waters to present-day levels, erosional activity has been minimal. Organic deposits have developed in depressions in the land surface, and some alluvial deposits have been laid down along water courses (Gartner 1980; VanDine 1980).

EXTRACTIVE ACTIVITY

At the time of field investigation, fifty pits located throughout the report area were identified and plotted on Maps 1 and 2. These extractive sites were at various stages of development. Many of the pits had been inactive for a considerable period of time, while some had been worked recently. Pit-run aggregate was actively being extracted from two of the pits for local road-maintenance and construction purposes during field investigation. Several of the sources were located in small deposits, in some cases too small to delineate on the maps, and were near depletion. Other pits have been opened to supply only low-specification borrow material.

SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 1 indicates the deposits which contain granular materials. Many of these potential resource areas have limited value for reasons of size, thickness and material quality. Consequently, only the most significant sources are suggested for possible resource protection.

The selected sand and gravel resource areas are shown on Map 2. A total of seven areas have been selected for possible resource protection at the primary level. The deposits contain sand and gravel deposited in ice-contact, outwash and glacio-lacustrine environments. The deposits contain most of the report area's potential resources of crushable gravel. The seven Primary Resource Areas occupy a total of 670 acres (270 ha) currently available for extraction and contain granular resources of approximately 37 million tons (34 million tonnes).

Several deposits have also been selected at the secondary level of significance. These deposits are limited to a certain extent with respect to aggregate quality or the amount of available resources. However, they add significantly to the resource base of the report area and provide important alternative sources, especially for local use. Some secondary deposits may also be capable of supplying small amounts of crushable gravel.

In McKinnon Township and the southern part of Mongowin Township the identified resources appear adequate to meet most aggregate requirements. The selected deposits in these areas are considered well suited for extraction of pit-run aggregate and are potential sources of crushable gravel. In southern Shedden Township, two relatively large deposits contain locally significant resources of low-specification aggregate. However, in the remainder of the report area, aggregate resources are considered limited, especially resources of crushable gravel.

Careful management is necessary to ensure the continued availability of as much of the remaining resources as possible.

Information concerning the quality of the sand and gravel is lacking for the report area. Based on field observations, however, the aggregate appears hard and durable and suitable for a variety of aggregate applications. Use of the material in structural concrete may be limited by the presence of argillite, greywacke and sandstone clasts of Huronian Supergroup in the area's pits, especially in Hallam, McKinnon, Mongowin and Foster Townships. These clasts are potentially alkali-reactive (Rogers 1983) and testing of the aggregate is recommended prior to use in concrete products.

Selected sand and gravel resources areas are not permanent, single land use units. They represent areas in which a major resource is believed to exist and may be reserved wholly or partially for extractive development and/or resource protection.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Sand and Gravel Resource Area 1 is an ice-contact deposit located in southwestern Shedden Township. Two pits have been opened in the deposit. Faces in pit no. 11 exposed between 5 and 12 feet (1.5 and 4 m) of medium to coarse sand with some fine gravel. The sand was overlain by 1 foot (0.3 m) of silt and clay which would require stripping. A sample from the pit contained 21 percent gravel, 74 percent sand and 5 percent fines (Figure 2a). Sand was also observed in the 10- to 20-foot (3 to 6 m) faces of pit no. 12 and along the hydro line which crosses the resource area. The sandy aggregate in the deposit appears suitable for uses including Granular Base Course C and fill. Blending would probably be required for asphaltic sand products.

Resource Area 1 occupies 105 acres (42 ha), of which 80 acres (32 ha) are considered available for extraction. Assuming an average depth of 12 feet (4 m), available resources are estimated to be 2.4 million tons (2.2 million tonnes). The deposit is readily accessible via King's Highway 17.

SELECTED SAND AND GRAVEL RESOURCE AREA 2

A wave-modified outwash deposit located near Spanish in southern Shedden Township has also been selected at the primary level of significance. The outwash material has been reworked by glacial lake waters forming a number of beach terraces along the southern slopes of the resource area.

Four pits with faces ranging from 5 to 15 feet (1.5 to 5 m) high have been developed in the deposit. In pit nos. 15 and 16 the aggregate consisted of well stratified sand and gravelly sand. A sample from pit no. 16 contained 24 percent gravel, 74 percent sand and 2 percent fines (Figure 2a). Thin silt seams were observed in the upper faces of pit no. 15. In pit no. 18 the aggregate was poorly sorted and ranged from silty fine sand to gravelly sand. Silt and clay up to 3 feet (1 m) thick overlies the sand in places within this pit. Stripping of this fine material would be neccessary to avoid contamination of the underlying aggregate. In general, the aggregate in the deposit appears well suited for pit-run uses. Blending would probably be required for asphaltic sand production.

Resource Area 2 occupies a total area of 125 acres (51 ha). Residential development at Spanish together with previous extraction has reduced the area currently available to 80 acres (32 ha). Assuming an average deposit thickness of 15 feet (5 m), resources of sand and gravel are estimated to be 3 million tons (2.7 million tonnes.). Access to the area is provided by several gravel-surfaced roads.

SELECTED SAND AND GRAVEL RESOURCE AREA 3

Selected Sand and Gravel Resource Area 3 is an ice-contact deposit located in southeastern Hallam Township. The deposit flanks a bedrock ridge to the north and one pit has been opened in the resource area. Pit no. 33 is worked in two levels; a lower 30-foot (9 m) face and an upper 40-foot (12 m) face. The material exposed in these faces consists predominantly of fine to coarse gravel. Pockets of sandy aggregate exist within the gravel and in places the gravel may be coated with fines. A sample containing 75 percent gravel, 20 percent sand and 5 percent fines was taken from the pit (Figure 3a). The Ontario Ministry of Transportation and Communications report that the aggregate is suitable for uses including 16 mm Crushed Type A and B as well as granular base course. The sand fraction of the aggregate would require blending for asphaltic sand and sand control may be necessary in sections for crushing. During field investigation the pit was being utilized for local road maintenance.

Although Resource Area 3 has an available area of only 3 acres (1 ha), it is considered important as it is the major source of crushable gravel in the township. Assuming an average depth of 50 feet (15 m), aggregate resources are approximately 0.4 million tons (0.4 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 4

Selected Sand and Gravel Resource Area 4 consists of four ice-contact ridges, designated 4a to 4d on Map 2, in central McKinnon Township. The pits developed in these deposits have been the major aggregate sources in the township.

Two pits have been opened in Area 4a. In pit no. 36, 10 to 20 feet (3 to 6 m) of medium to coarse gravel with localized pockets of medium sand is exposed. A sample from the pit

contained 62 percent gravel, 37 percent sand and 1 percent fines (Figure 3a). The aggregate appears suitable for a variety of aggregate uses including crusher-run products. At the time of field investigation, aggregate from the pit was being utilized for local cottage road development. Pit no. 37, situated just west of pit no. 36, is strictly a sand source.

Pit no. 38 has been developed in Area 4b. The 20-foot (6 m) faces in this pit reveal 10 feet (3 m) of sandy gravel over 10 feet (3 m) of gravelly sand. A sample of the aggregate contained 47 percent gravel, 52 percent sand and 1 percent fines (Figure 3a). The gravel in the pit is generally too fine for crushing, however, the material appears well suited for pit-run uses. Similar quality aggregate likely exists in the undeveloped parts of the deposit.

Area 4c is located west of Evangeline Lake. Fine to coarse gravel is exposed in the 25-foot (8 m) faces of pit no. 39 which has been opened in the area. A sample containing 57 percent gravel, 41 percent sand and 2 percent fines was taken of this material (Figure 3a). Although no quality data are available for the pit, it is likely that the aggregate is suitable for both crusher-run and pit-run uses. Sand control measures may be necessary in sections for crushing. Seismic line EP-GT-3 indicates the possibility that aggregate extends to a significant depth in the northern end of the deposit.

Unlike Areas 4a to 4c, subsurface data are presently lacking for Area 4d. However, Area 4d was deposited in a similar geological environment as Areas 4a to 4c, and fine to medium gravel is exposed on the surface of the deposit. Therefore, the aggregate in Area 4d is expected to have similar potential.

Resource Area 4 occupies 65 acres (26 ha), of which 57 acres (23 ha) are considered available for extraction. Assuming average

deposit values of 20 feet (6 m) for Areas 4a, 4b, and 4d, and 25 feet (8 m) for Area 4c, available sand and gravel resources are estimated to total 3.2 million tons (2.9 million tonnes). Access to the area is provided by a gravel-surfaced road, which extends from Lee Valley (in Hallam Township) to Evangeline Lake, and bush roads which branch off this road.

SELECTED SAND AND GRAVEL RESOURCE AREA 5

Selected Sand and Gravel Resource Area 5 is located along the southern slopes of the La Cloche Mountains in southern McKinnon Township. The deposit consists of deltaic material which has been reworked by wave action in an ancestral Lake Huron. A sequence of beach terraces was formed on the 150- to 200-foot (46 to 61 m) frontal slopes of the resource area which represent different shoreline stages in the lake.

No pits have been opened in the deposit and subsurface information is lacking. The resource area, however, is considered to contain significant potential resources of sand and gravel suitable for future extractive development. Several shallow test pits were excavated in the surface of the deposit revealing material ranging from medium to coarse sand, to sandy fine to coarse gravel. The material is likely suitable for a variety of aggregate uses.

Approximately 300 acres (121 ha) are currently available for extraction in Resource Area 5. Assuming an average depth of 25 feet (8 m) for the deposit, aggregate resources are estimated to be 18.8 million tons (17 million tonnes). The area is currently inaccessible by road.

SELECTED SAND AND GRAVEL RESOURCE AREA 6

Selected Sand and Gravel Resource Area 6 is located west of Whitefish Falls in southern Mongowin Township. Similar to Resource Area 5, Area 6 has been deposited along the southern slopes of the La Cloche Mountains and has been modified by wave action in an ancestral Lake Huron. A number of beach terraces have been developed through reworking of the ice-contact material which forms the core of the deposit.

Pit no. 43 has been developed in the deposit. The 20 - to 40-foot (6 to 12 m) faces in the pit consist of well stratified gravelly sand with occasional pockets of poorly sorted coarse gravel. The gravelly sand unit was sampled and contained 21 percent gravel, 73 percent sand and 6 percent fines (Figure 4a). The gravel content of a 8- to 15-foot (2 to 5 m) thick pocket of coarse gravel was estimated to be 70 percent. Although no quality data are available for the pit, it is likely that pit-run granular base course and fill may be the most readily produced aggregate. With selective extraction and sand control measures, the pockets of coarse gravel within the pit may be utilized for crushing. Similar quality material to that exposed in the pit is expected to exist in the presently undeveloped parts of the deposit.

Resource Area 6 occupies 134 acres (54 ha), of which 130 acres (53 ha) are considered currently available for extraction. Assuming an average deposit thickness of 25 feet (8 m), sand and gravel resources are estimated to total 8.1 million tons (7.3 million tonnes). Access to the area is provided by a system of recently constructed cottage access roads which parallel the Lake Huron shoreline.

SELECTED SAND AND GRAVEL RESOURCE AREA 7

An ice-contact ridge in southeastern Foster Township has been

selected at the primary level of significance. Faces in pit no. 50, which has been developed in the deposit, range from 15 to 20 feet (5 to 6 m) high. The dominant material exposed in the pit is well-stratified, sandy fine aggregate which appears well suited for pit-run aggregate uses. There also exist lenses of coarse gravel which may be suitable for crushing with sand control and selective extraction measures. A sample taken from the pit contained 41 percent gravel, 56 percent sand and 3 percent fines (Figure 4a).

Resource Area 7 has a total area of 21 acres (8 ha). Cultural constraints and previous extraction reduce the area currently available to 18 acres (7 ha). Assuming an average deposit depth of 25 feet (8 m), available aggregate resources are approximately 1.1 million tons (1.0 million tonnes). The deposit is readily accessible via a cottage and forest access road which parallels Hannah Lake.

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

Four deposits in the eastern part of Shedden Township and one along the township's western boundary have been selected as secondary resource areas. The deposits consist of undifferentiated ice-contact stratified drift and are situated along the south side of bedrock ridges. Although the amount of available aggregate in these deposits is limited, the material remaining in the deposit is considered acceptable for local use. The deposits in which pit nos. 4, 19 and 20 are located consist predominantly of sand. In pit nos. 19 and 20 the sand is thinly overlain by silt and clay which would require stripping. Higher concentrations of gravel were observed in pit nos. 5 and 7. Minor amounts of crushed stone may be available from these pits with selective extraction of coarser gravel pockets and sand control measures.

Four deposits surrounding the Town of Webbwood in Hallam Township have also been selected at the secondary level. They consist of fine to medium sand deposited in outwash and glaciolacustrine environments. Fill may be the most readily available product from these deposits. However, in the deposit which contains pit nos. 27 and 28 as well as the small deposit just south of the town, the sand is slightly coarser and may be suitable for Granular Base Coarse C and asphaltic blending sand. In the westernmost deposit the depth of extraction may be restricted in places by a high water table. In addition, limited amounts of sandy aggregate suitable for local use are available from an ice-contact deposit in the southeastern part of Hallam Township.

In McKinnon Township, three deposits have been selected at the secondary level. Two of these deposits are located east of Resource Area 4a. They consist of ice-contact stratified drift and are sand sources suitable for low-specification aggregate uses. In places, bedrock may restrict the depth of extraction in these deposits as indicated by seismic line EP-GT-1. The other deposit is situated along the border of McKinnon and Mongowin Townships near the shore of Lake Huron. Although no quality or subsurface data are available for this wave-modified ice-contact deposit, it appears to have been deposited in a similar geological environment as Resource Area 6. Therefore, it is expected to have a comparable resource potential. The deposit is currently inaccessible by road.

Two secondary resource areas are located in Mongownin Township. Sandy fine gravel is exposed in the ice-contact deposit situated along the northern border of the township. Although only small quantities of aggregate are available from this deposit, it is considered an important local source as existing aggregate resources in the area are limited. The glaciolacustrine beach deposit located just north of Freud Bay in the southern part of

the township also has potential for future extractive development. Coarse sand with abundant gravel was observed on the surface of the deposit and similar material is expected to be available at depth.

The final area selected at the secondary level is located in southern Foster Township. One pit (pit no.46) has been opened in this ice-contact deposit with faces ranging from 10 to 50 feet (3 to 15 m) high. Sand with fine gravel is the dominant material exposed in the faces although pockets of medium to coarse gravel occur locally. A sample containing 32 percent gravel, 63 percent sand and 5 percent fines was taken from the pit (Figure 4a). The remaining resources in this deposit appear well suited for local pit-run uses. Seismic line EP-GT-5 indicates that at least 14 feet (4 m) of aggregate may be available from beneath the floor of the pit.

SAND AND GRAVEL RESOURCES OF TERTIARY SIGNIFICANCE

The remaining aggregate resources in the area have been classified at the tertiary level. They represent deposits in which the material is of poor quality, or where quality information is lacking, or in which extremely limited resources are available. Most of the tertiary deposits consist of sand deposited in glaciolacustrine and outwash environments. Because the sand is often excessively fine and poorly graded, the use of these deposits is generally limited to granular borrow or fill. Despite these drawbacks, the deposits may have importance when short haul distances are of more importance then material quality. In addition, subsurface testing may increase the resource potential of an ice-contact deposit located between Resource Areas 4b and 4c in McKinnon Township. Slightly dirty sandy gravel was observed on the surface of this deposit, but information concerning the possible continuation of aggregate to greater depth is lacking.

BEDROCK RESOURCE POTENTIAL

An alternative source of aggregate within the study area is bedrock-derived aggregate. The Precambrian Shield rocks which underlie the area consist predominatly of Archean granitic rocks, metasedimentary rocks of the Huronian Supergroup and Nipissing diabase. Precambrian rocks often show wide variations in mineralogy, texture (grain size) and degree of weathering, even within specific rock types and over relatively short distances. Some rock types may slowly react with cement eventually leading to concrete deterioration. As these factors are considered important in determining the suitability of bedrock for use as aggregate, any site under consideration should be tested in detail prior to extractive development. For detailed mapping and descriptions of the rocks in the area the reader is referred to reports and mapping by Card (1968; 1976; 1978; 1984), Card et al. (1977), Robertson (1977), Robertson and Siemiatkowska (1971) and Robertson et al. (1972).

Of the rock types in the report area, the Nipissing diabase is considered best suited for possible extraction. As well as being a potential source of high specification aggregate, diabase can be well suited for other industrial mineral applications. Factors such as the purity of the diabase, the abrasive nature of these rocks on crushing equipment, joint pattern and market potential would influence quarry development. Previous investigation concerning diabase resources in the surrounding area has been reported by Card (1976) and Robertson (1977).

The granitic rocks may also be suited for extraction and have been utilized for crushed stone elsewhere in Ontario. They may, however, deleteriously react with cement over time (Rogers 1983). The argillities, greywackes and sandstones of the Huronian Supergroup are known to be alkali reactive and should be avoided for use in concrete in heavy duty applications.

Although no quarries have presently been established to extract bedrock-derived aggregate in the report area, the bedrock resources may increase in importance if future demands for high specification aggregate increase. Such demands may be experienced as existing sand and gravel resources near depletion or if large construction projects are initiated in the area.

SUMMARY

Sand and gravel deposits in the report area are the product of glacial activity. Seven Primary Resource Areas have been selected for possible resource protection. These areas are considered to have the greatest potential for extractive development and consist of aggregate ranging from sand to crushable gravel. Several deposits of secondary significance have also been selected and these areas are generally well suited for local aggregate use. Deposits containing the largest quantities of available aggregate are situated in McKinnon Township and the southern parts of Shedden and Monogowin Townships. Outside these areas the resource base is limited, especially with respect to reserves of crushable gravel. Care should be taken to ensure the continued availability of as much of the resource areas as possible.

An alternative source of aggregate in the study area is the bedrock. The bedrock consists of a complex array of metasedmentary and intrusive rocks, of which Nipissing diabase is considered the best suited for possible crushed stone production.

Enquries regarding the aggregate inventory of Hallam, McKinnon, Mongowin, and Foster Townships, District of Sudbury, and Shedden Township, District of Algoma, should be directed to the Ontario Ministry of Natural Resources either at the Espanola District Office, Box 1340, 148 Fleming St., Espanola, Ontario, P0P 1C0 (Tel. (705) 869-1330) or the Northeastern Regional Office, 199

Larch St., Sudbury, Ontario, P3E 5P9 (Tel. (705) 675-4120), or to the Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Northern Affairs and Mines, Room M1B-45, Macdonald Block, Queen's Park, Toronto, Ontario, M7A 1W3 (Tel. (416) 965-1663).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES HALLAM, McKINNON, MONGOWIN, AND FOSTER TOWNSHIPS, DISTRICT OF SUDBURY, AND SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA			
1	S-IC	7 (3)	0.4 (0.4)
2	G-IC	8 (3)	0.3 (0.3)
	S-IC	135 (55)	4.3 (3.9)
	S-LB-OW	125 (51)	4.7 (4.3)
3	G-IC	24 (10)	0.3 (0.3)
	S-IC	5 (2)	0.1 (0.1)
	G-LB	5 (2)	0.1 (0.1)
	S-LB	1 (0.4)	0.1 (0.1)
	S-OW	105 (42)	2.1 (1.9)
4	S-LB	2 (0.8)	0.1 (0.1)
		420 (170)	12.3 (11.2)
HALLAM TOWNSHIP, DISTRICT OF SUDBURY			
1	G-IC	7 (3)	0.9 (0.8)
	S-OW-LP	160 (65)	8.0 (7.3)
2	S-LP-OW	430 (174)	12.9 (11.7)
	S-OW-LP	8 (3)	0.2 (0.2)
3	G-IC	9 (4)	0.2 (0.2)
	S-IC	3 (1)	0.1 (0.1)
	S-LB-IC	5 (2)	0.1 (0.1)

*Deposits within the cultural constraint boundary surrounding Webbwood have been omitted on all tables.

TABLE 1 | **TOTAL SAND AND GRAVEL RESOURCES, HALLAM, McKINNON, MONGOWIN, AND FOSTER TOWNSHIPS, DISTRICT OF SUDBURY, AND SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA**

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
	S-LP	2700 (1090)	54 (49)
	S-LP-OW	1620 (660)	32.5 (29.5)
		4950 (2000)	109 (99)
McKINNON TOWNSHIP, DISTRICT OF SUDBURY			
1	G-IC	65 (26)	3.6 (3.3)
	G-LB-LD	300 (121)	18.8 (17.0)
2	S-IC	18 (7)	0.5 (0.5)
	S-LB-IC	130 (53)	6.2 (5.6)
3	S-IC	18 (7)	0.4 (0.4)
	S-LB-LP	430 (174)	8.6 (7.8)
	S-LP	210 (85)	4.2 (3.8)
	S-LP-IC	80 (32)	1.6 (1.4)
	S-OW	190 (77)	3.8 (3.4)
4	G-IC	75 (30)	0.8 (0.7)
		1520 (620)	48.5 (44.0)
MONGOWIN TOWNSHIP, DISTRICT OF SUDBURY			
1	S-LB	19 (8)	1.2 (1.1)
	S-LB-IC	134 (54)	8.4 (7.6)
2	G-IC	2 (0.8)	0.1 (0.1)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, HALLAM, McKINNON, MONGOWIN, AND FOSTER TOWNSHIPS, DISTRICT OF SUDBURY, AND SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
	S-LB	18 (7)	0.7 (0.6)
	S-LB-IC	5 (2)	0.2 (0.2)
3	S-IC-LP	5 (2)	0.1 (0.1)
	S-LB	37 (15)	0.7 (0.6)
	S-LB-LP	200 (81)	4.0 (3.6)
		420 (170)	15.4 (14.0)
FOSTER TOWNSHIP, DISTRICT OF SUDBURY			
1	G-IC	21 (8)	1.3 (1.2)
	S-IC	5 (2)	0.3 (0.3)
	S-OW-LP	75 (30)	3.8 (3.4)
2	S-IC	2 (0.8)	0.1 (0.1)
3	S-IC	1 (0.4)	0.1 (0.1)
	S-OW-LP	255 (103)	5.1 (4.6)
		360 (146)	10.6 (9.6)
TOTAL FOR REPORT AREA		7700 (3100)	196 (178)

TABLE 2 | SAND AND GRAVEL PITS, HALLAM, McKINNON, MONGOWIN, AND FOSTER TOWNSHIPS, DISTRICT OF SUDBURY, AND SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA						
1	-	11	6	5 (1.5)	sand	
2	-	5	6	10-20 (3-6)	30-50	near depletion
3	-	10	5	4 (1.2)	sand	bedrock exposed on pit floor
4	-	2	5	20-25 (6-8)	sand	
5	-	3	4	10-20 (3-6)	10-30	gravel in pockets
6	-	SW¼	SEC 23	10 (3)	till	
7	S31-38	SW¼	SEC 19	5-12 (1.5-4)	20-50	
8	S31-43	NW¼	SEC 28	20 (6)	10-30	near depletion
9	S31-43	NW¼	SEC 28	15-20 (5-6)	50-60	near depletion
10	S31-36	SE¼	SEC 29	2-4 (0.6-1.2)	sand, gravel	bedrock exposed on pit floor
11	S31-40	S½	SEC 29	5-12 (1.5-4)	5-20	overlain by 1 foot (0.3m) thick layer of silt and clay
12	S31-37	NE¼	SEC 32	10-20 (3-6)	sand	
13	S31- 2	SW¼	SEC 28	10-30 (3-9)	10	near depletion
14	S31- 3	SE¼	SEC 28	30-40 (9-12)	sand	near depletion
15	S31-42	SW¼	SEC 34	8-15 (2-5)	10-20	
16	S31-46	SW¼	SEC 34	12-15	20-25 (4-5)	
17	-	W ½	SEC 39			overgrown
18	-	E ½	SEC 39	5-15	5-10 (1.5-5)	lenses of silt and clay up to 3 feet (1m) thick overlie the aggregate

TABLE 2 | SAND AND GRAVEL PITS, HALLAM, McKINNON, MONGOWIN, AND FOSTER TOWNSHIPS, DISTRICT OF SUDBURY, AND SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
19	-	NW¼	SEC 35	10-20 (3-6)	10	thinly overlain by silt and clay
20	S31-49	NW¼	SEC 35	30-40 (9-12)	10	thinly overlain by silt and clay, bedrock exposed in pit face
21	-	NW¼	SEC 35	20 (6)	5	near depletion
22	-	SE¼	SEC 35			depleted
23	S31- 8	NE¼	SEC 36	10-30 (3-9)	mainly sand	near depletion, localized gravel pockets
HALLAM TOWNSHIP, DISTRICT OF SUDBURY						
24	-	11	4	30-40 (9-12)		depleted to bedrock
25	-	9	5	5-10 (1.5-3)	sand	partially over-grown
26	E1-50	9	6	3-5 (1-1.5)	sand	overgrown
27	E1-40	6	6	10-20 (3-6)	sand	overgrown
28	E1-57	5	5,6	20-25 (6-8)	sand	
29	E1-49	6	5	10 (3)	sand	
30	E1- 7	3	5	60 (18)		near depletion
31	-	6	2	5-10 (1.5-3)	30	near depletion
32	W20-6	1	2	15-40 (5-12)	30-50	near depletion
33	W20-5	3	2	70 (21)	30-75	worked in two levels
34	-	2	1	5-10 (1.5-3)	20-30	
35	-	1,2	1	5 (1.5)	sand	
McKINNON TOWNSHIP, DISTRICT OF SUDBURY						
36	W20-45	7	5	10-20 (3-6)	50-70	

TABLE 2 | SAND AND GRAVEL PITS, HALLAM, McKINNON, MONGOWIN, AND FOSTER TOWNSHIPS, DISTRICT OF SUDBURY, AND SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
37	-	7,8	5	5-12 (1.5-4)	sand	
38	W20-43 W20-44	8	4	20 (6)	30-50	
39	-	9	3	25 (8)	50-60	
MONGOWIN TOWNSHIP, DISTRICT OF SUDBURY						
40	-	8	6	7-12 (2-4)	30-70	near depletion
41	W20-16	5	4			depleted
42	-	5	4	5-15 (1.5-5)	sand	near depletion
43	-	4	Wallace Mine Locations	20-40 (6-12)	20-70	
FOSTER TOWNSHIP, DISTRICT OF SUDBURY						
44	-	8	3	20 (6)	till	
45		9,10	2.	10-50 (3-15)	40-60	near delpetion
46		7	2	10-50 (3-15)	30-40	
47		7	2			depleted to bedrock
48		8	1	5-8 (1.5-2)	40-50	bedrock exposed in face, aggregate overlain by silt and clay
49		4,5	1	5-10 (1.5-3)		depleted to bedrock
50		1,2	1	15-20 (5-6)	30-45	

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, HALLAM, McKINNON, MONGOWIN, AND FOSTER TOWNSHIPS, DISTRICT OF SUDBURY, AND SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA

1	2	3	4	5	6	7
Deposit No.	UNLICENCED AREA Acres (Hectares)	CULTURAL SETBACKS Acres (Hectares)	EXTRACTED AREA Acres (Hectares)	AVAILABLE AREA Acres (Hectares)	ESTIMATED DEPOSIT THICKNESS Feet (Metres)	AVAILABLE AGGREGATE Millions of Tons (Tonnes)
SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA						
1	105 (42)	20 (8)	5 (2)	80 (32)	12 (4)	2.4 (2.2)
2	125 (51)	40 (16)	5 (2)	80 (32)	15 (5)	3.0 (2.7)
	230 (93)	60 (24)	10 (4)	160 (65)		5.4 (4.9)
HALLAM TOWNSHIP, DISTRICT OF SUDBURY						
3	7 (3)	0 (0)	4 (2)	3 (1)	50 (15)	0.4 (0.4)
McKINNON TOWNSHIP, DISTRICT OF SUDBURY						
4a	20 (8)	0 (0)	4 (2)	16 (6)	20 (6)	0.8 (0.7)
4b	18 (7)	0 (0)	2 (0.8)	16 (6)	20 (6)	0.8 (0.7)
4c	24 (10)	0 (0)	2 (0.8)	22 (9)	25 (8)	1.4 (1.3)
4d	3 (1)	0 (0)	0 (0)	3 (1)	20 (6)	0.2 (0.2)
	65 (26)	0 (0)	8 (3)	57 (23)		3.2 (2.9)
5	300 (121)	0 (0)	0 (0)	300 (121)	25 (8)	18.8 (17.0)
	365 (148)	0 (0)	8 (3)	355 (144)		22.0 (20.0)
MONGOWIN TOWNSHIP, DISTRICT OF SUDBURY						
6	134 (54)	0 (0)	4 (2)	130 (53)	25 (8)	8.1 (7.3)
FOSTER TOWNSHIP, DISTRICT OF SUDBURY						
7	21 (8)	1 (0.4)	2 (0.8)	18 (7)	25 (8)	1.1 (1.0)
Total for Report area	760 (310)	61 (25)	28 (11)	670 (270)		37.0 (34)

TABLE 4 - SUMMARY OF GEOPHYSICS DATA, HALLAM. MCKINNON, MONGOWIN AND FOSTER TOWNSHIPS, DISTRICT OF SUDBURY, AND SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA

SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA

- NONE -

HALLAM TOWNSHIP, DISTRICT OF SUDBURY

- NONE -

McKINNON TOWNSHIP, DISTRICT OF SUDBURY

Line Number:	EP-GT-1	
Line Direction:	North-south	
Method:	Hammer Seismic	
Location:	Lot 7, Concession 5	
Elevation:	Approx. 800 feet (244 m) a.s.l.	
Seismic Data:	Number of Layers:	2
	Layer Velocities:	V_1 = 1140 ft./sec. (345 m/sec.)
		V_2 = 12000 ft./sec. (3650 m/sec.)
	Layer Thickness:	D_1 = 9 ft. (3 m)
	Interpretation:	Approx 9 feet (3 m) of sand over bedrock.

Line Number:	EP-GT-2	
Line Direction:	East-West	
Method:	Hammer Seismic	
Location:	Lot 8, Concession 4	
Elevation:	Approx. 800 feet (244 m) a.s.l.	
Seismic Data:	Number of Layers:	1
	Layer Velocities:	V^1 = 2730 ft./sec. (830 m/sec.)
	Interpretation:	A minimum of 37 feet (11 m) of till or sand and gravel.

Line Number:	EP-GT-3	
Line Direction:	North-South	
Method:	Hammer Seismic	
Location:	Lot 9, Concession 3	
Elevation:	Approx 750 feet (229 m) a.s.l.	
Seismic Data:	Number of Layers:	2
	Layer Velocities:	V_1 = 1850 ft./sec. (560 m/sec.)
		V_2 = 14000 ft./sec. (4250 m/sec.)
	Layer Thickness:	D_1 = 38 ft. (12 m)
	Interpretation:	Approx 38 feet (12 m) of sand and gravel over bedrock

Line Number:	EP-GT-4
Line Direction:	East-West
Method:	Hammer Seismic
Location:	Lot 8, Concession 2
Elevation:	Approx. 750 feet (229 m) a.s.l.

TABLE 4 - SUMMARY OF GEOPHYSICS DATA, HALLAM. MCKINNON, MONGOWIN AND FOSTER TOWNSHIPS, DISTRICT OF SUDBURY, AND SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA

Seismic Data:	Number of Layers:	2
	Layer Velocities:	V_1 = 1430 feet./sec. (435 m/sec.)
		V_2 = 4650 ft./sec. (1420 m/sec.)
	Layer Thickness:	D_1 = 34 ft. (10 m)
	Interpretation:	Approx. 34 feet (10 m) of sand and gravel over wet granular material.

MONGOWIN TOWNSHIP, DISTRICT OF SUDBURY

- NONE -

FOSTER TOWNSHIP, DISTRICT OF SUDBURY

Line Number:	EP-GT-5	
Line Direction:	East-West	
Method:	Hammer Seismic	
Location:	Lot 7, Concession 2 Floor of pit #46	
Elevation:	Approx 820 feet (250 m) a.s.l.	
Seismic Data:	Number of Layers:	2
	Layer Velocities:	V_1 = 1550 ft./sec. (470 m/sec.)
		V_2 = 4350 ft./sec. (1330 m/sec.)
	Layer Thickness:	D_1 =14 ft. (4 m)
	Interpretation:	Approx. 14 feet (4 m) of gravelly sand over wet granular material.

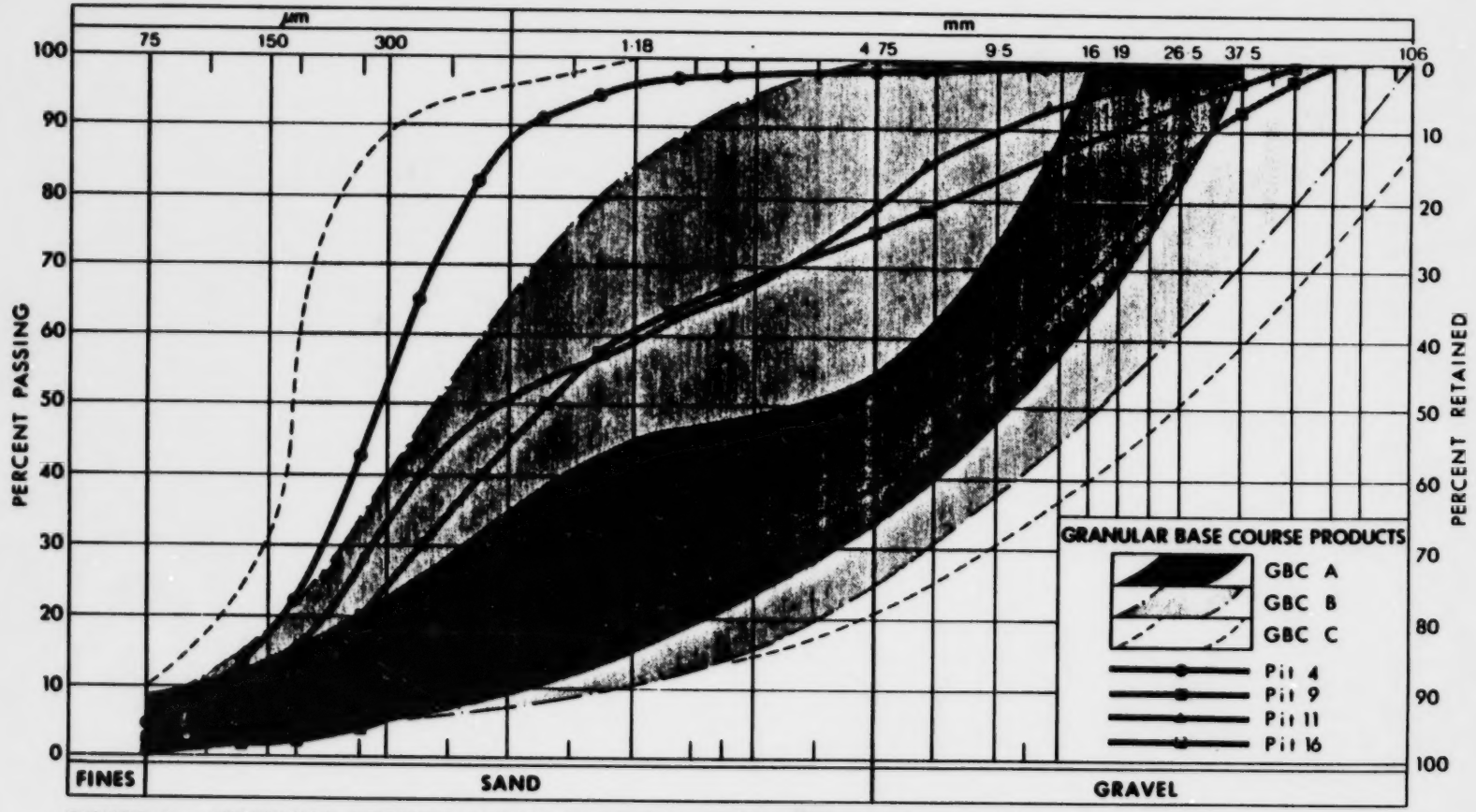

FIGURE 2a; AGGREGATE GRADING CURVES, SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

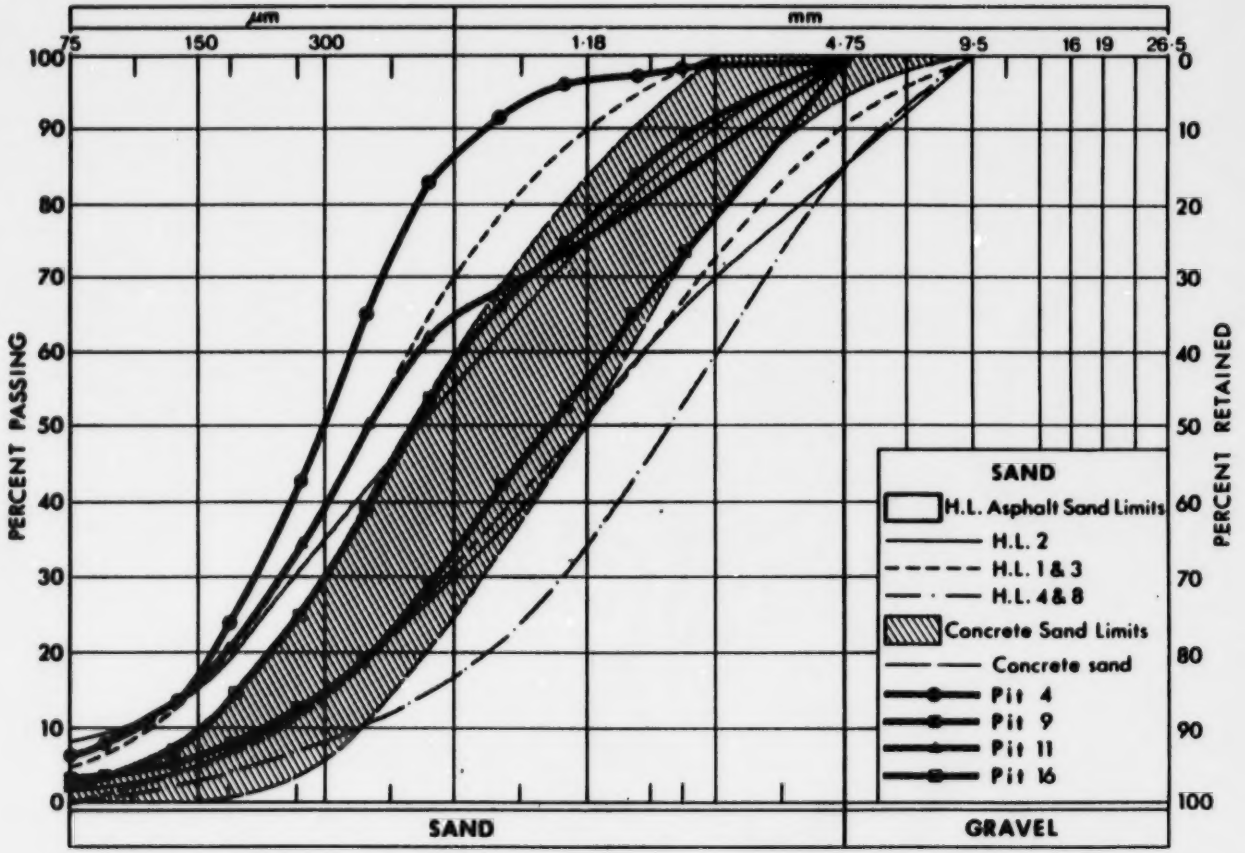

FIGURE 2b; AGGREGATE GRADING CURVES, SHEDDEN TOWNSHIP, DISTRICT OF ALGOMA;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

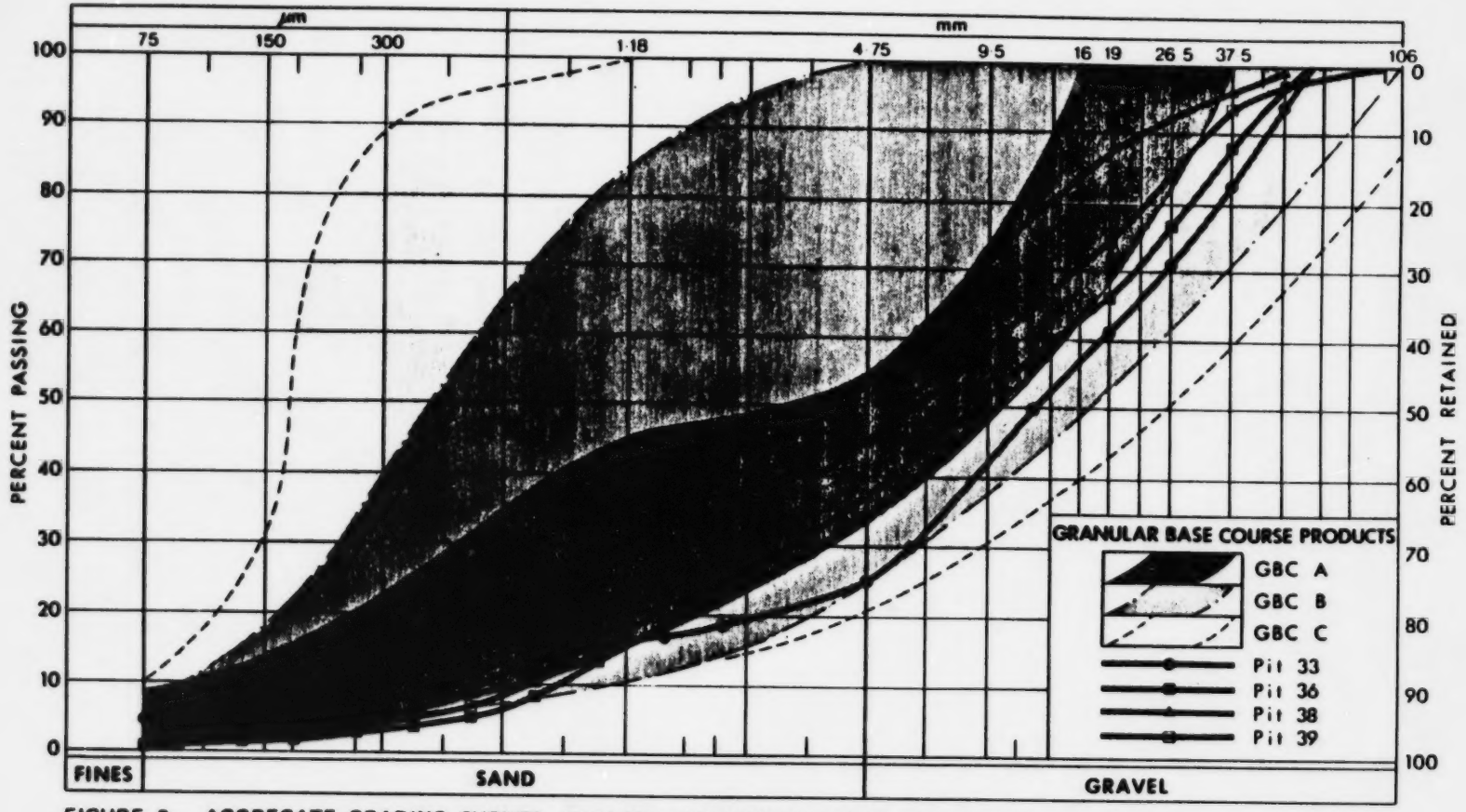

FIGURE 3a; AGGREGATE GRADING CURVES, HALLAM and McKINNON TOWNSHIPS, DISTRICT OF SUDBURY;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

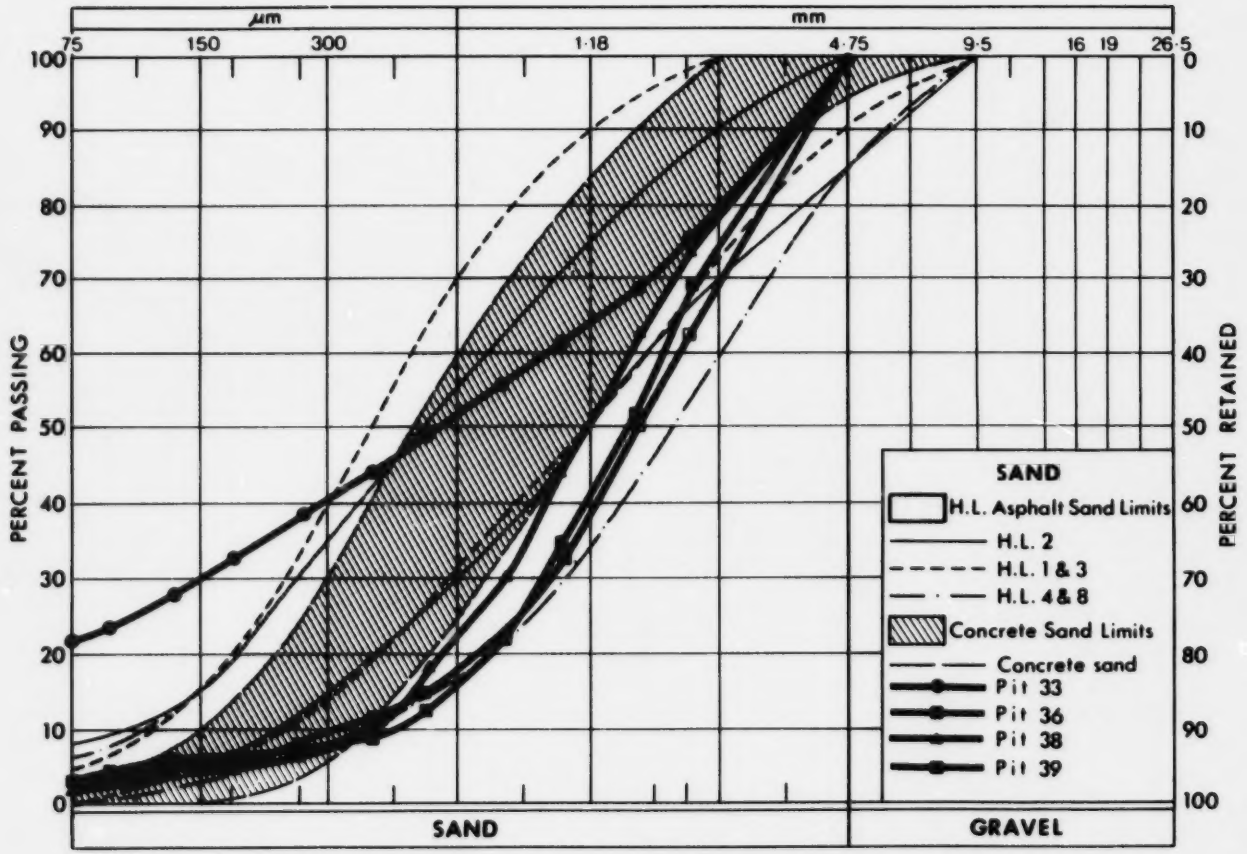

FIGURE 3b; AGGREGATE GRADING CURVES, HALLAM and McKINNON TOWNSHIPS, DISTRICT OF SUDBURY;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

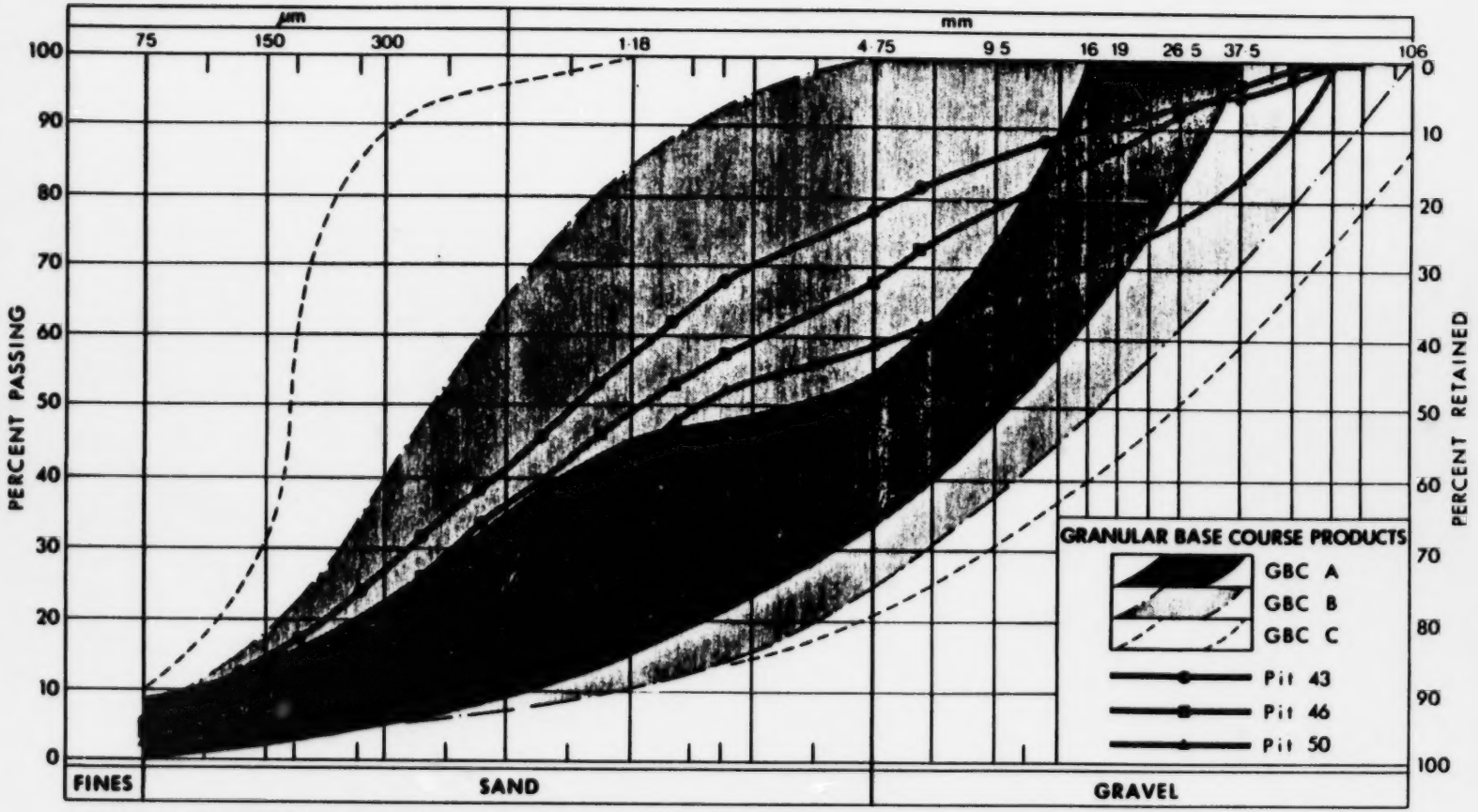

FIGURE 4a; AGGREGATE GRADING CURVES, MONGOWIN and FOSTER TOWNSHIPS, DISTRICT OF SUDBURY;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

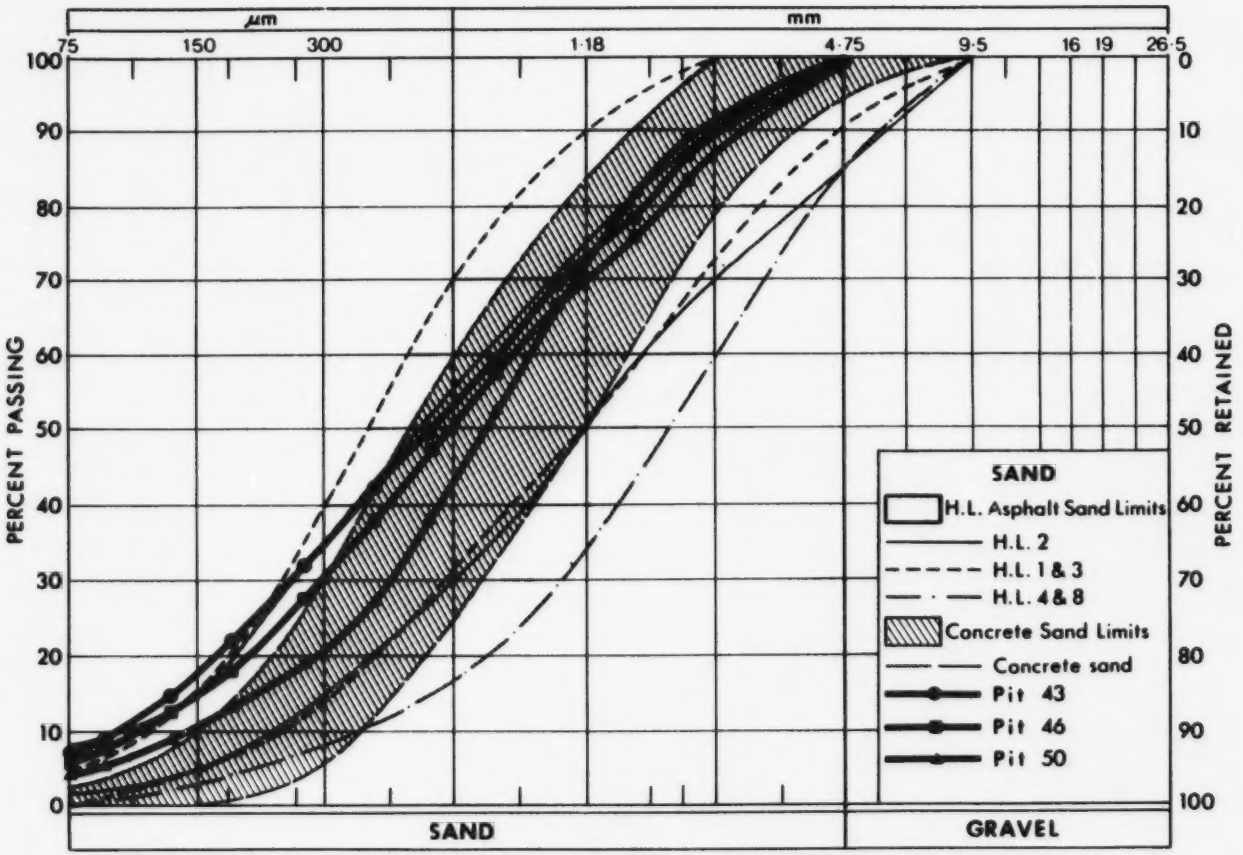

FIGURE 4b; AGGREGATE GRADING CURVES, MONGOWIN and FOSTER TOWNSHIPS, DISTRICT OF SUDBURY;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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APPENDIX A - PURPOSE, METHODOLOGY AND DATA PRESENTATION OF THE AGGREGATE RESOURCES INVENTORY*

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1982, the total tonnage of mineral aggregate extracted was 101 million tons (92 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1981).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where the deposits occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of the deposit is a function of its proximity to a market area, as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The

* **This Appendix is made up of the standard Introduction and Part I and II from the Aggregate Resources Inventory Paper (ARIP) series (for example, see ARIP 89, Aggregate Resources Inventory of the Central Part of the City of Timmins). The text has been modified slightly to correspond to the data presented in this Open File Report. The methodology and data presentation used in this OFR are identical to those used in the ARIP Series.**

purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of all the sand and gravel resources in the study area. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report involved the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References), as well as field examination of potential resource areas. Field methods included the examination of natural and manmade exposures of granular material. Observations were made at sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications (M.T.C.), the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, hammer seismic geophysical techniques were used to assess subsurface materials. Airphotos were used to determine the continuity of deposits, especially in areas of limited information.

Deposits with potential for further extractive development or those where existing data are scarce, were studied in greater detail. Representative layers in these deposits were sampled in 25- to 100-pound (11- to 450-kg) units from existing pit faces. The samples were analyzed for grain size distribution. In areas of limited subsurface exposure, geophysical surveys were undertaken using a portable hammer seismic unit. The location of geophysical traverse lines are shown on Map 1 and the geophysical data are summarized in Table 4.

In the office, the field data were supplemented by pit information on file with the Engineering Materials Office of the

Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The locations of additional sources were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were referred to at the preliminary assessment stage to identify areas of possible buried granular material. These records were used in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The base map was prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

Sand and Gravel Resources

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows: First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as water well logs. Original tonnage values can then be

calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3-m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factory (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however, the aggregate potential of these deposits is discussed in the report.

UNITS AND DEFINITIONS

Although most of the measurements and other primary data

available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after, or directly below, the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel are termed possible resources in accordance with terminology of the Ontario Resources Classification Scheme (Robertson 1975, p. 7) and with the Association of Professional Engineers of Ontario (1976).

PART II - DATA PRESENTATION AND INTERPRETATION

There are two maps, each portraying a different aspect of the aggregate resources in the report area. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

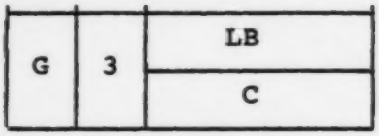
Map 1 is derived directly from existing surficial geology maps or from airphoto interpretation in areas where mapping is incomplete. The map represents a comprehensive inventory of sand and gravel deposits within the project area and serves as a base for the calculation of total sand and gravel resources. The map also represents a summary of all available information related to the quality of aggregate in the mapped deposits. Much of this information is contained in two symbols which appear on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular porportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

Deposit Symbol

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for

every deposit shown on Map 1. These components are illustrated by the following example:

Gravel Content — Geological Type



Thickness Class — Quality

This symbol identifies a lacustrine beach deposit 5 to 10 feet (1.5 to 3 m) thick containing more than 35 percent unprocessed gravel. Excess fines may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate makes up less than 35 percent of the whole deposit. The "G" indicates that the deposit probably contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix D) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

Texture Symbol

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken during field study. The data from which these symbols are derived has been plotted on grain size distribution graphs. The relative amounts of gravel, sand, and fines in the sampled material are shown graphically by the subdivision of a circle into proportional segments.

Other information shown on Map 1 are locations of geophysical traverse lines. In addition, all known sand and gravel pits, whether presently active or inactive, are shown by a dot symbol and a number which refers to the pit descriptions given in Table 2. Each description notes the location of the pit and the estimated face height and gravel content.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary, secondary and tertiary. These areas are identified on Map 2 by different shading patterns. Each area of primary significance is given a deposit number and all such deposits are shown by a dark tone on Map 2.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single, land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource

areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are indicated by a light tone on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas, they may contain large quantities of sand and gravel and should be considered as part of the aggregate supply of the municipality.

Areas of tertiary significance are outlined on the map by a solid line, but have no tone. They are neither rated nor considered to be important resource areas, because of their low available resources or because of possible difficulties in extraction. Such areas may be useful for local needs, but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the municipality is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain available sand and

gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6 m) and containing more than 35 percent coarse aggregate larger than the No. 4 (4.75 mm) sieve are considered to be most favourable for commercial development. Thinner deposits maybe valuable in municipalities with low total resources.

Aggregate Quality

The limitations of natural aggregate for various uses result from variations in the lithology of the particles making up the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: Gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the indicators deal with grain size distribution. The "gravel content", (G or S), indicates the suitability of aggregate for various uses. Deposits containing more than 35 percent coarse aggregate larger than the No. 4 (4.75 mm) sieve, and also a minimum of 20 percent larger than the 1 inch (25 mm) sieve, are considered to be favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess "fines" (high silt and clay content) may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles.

Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent "oversize" material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete and road-building aggregate, so must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is "lithology". Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine it suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits know to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit symbol indicates either "C", "O", "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Analyses of unprocessed samples obtained from test holes or pits are plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products: Granular Base Course (G.B.C.) A, B, and C; Hot-Laid (H.L.) Asphaltic Sand Nos. 1, 2, 3, 4 and 8; and concrete sand. By plotting the grading curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas, because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3.

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the Ontario Ministry of Natural Resources' District Office.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

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APPENDIX C - GLOSSARY

ABRASION RESISTANCE: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

ALKALI-AGGREGATE REACTION: A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although prefectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for concrete uses.

BLENDING: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

CLAST: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE: Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No.4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone, and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DOLOSTONE: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT: A general term for all unconsolidated rock debris transported from one place and deposited in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GLACIAL LOBE: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing a complex arrangement of glacial material and landforms.

GNEISS: A coarse textured metamorphic rock with the minerals arranged in parallel streaks or bands, but lacking schistosity. Gneiss is relatively rich in feldspar. Other common minerals found in this rock include quartz, mica, amphibole and garnet.

GRADATION: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

GRANULAR BASE COURSE: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALTIC) AGGREGATE: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2 and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY: The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

MAGNESIUM SULPHATE SOUNDNESS TEST: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually break down and give high losses in this test.

MELTWATER CHANNEL: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

PETROGRAPHIC EXAMINATION: An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of the aggregate.

PLEISTOCENE: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POSSIBLE RESOURCE: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

PRECAMBRIAN: The earliest geologic period extending from the consolidation of the earth's crust to the beginning of the Cambrian.

SHALE: A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

TILL: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX D - GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRRACES (ICT): These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

KAMES (K): Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuties. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the presence of excess fines (silt- and clay-sized particles).

ESKERS (E): Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC): This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

OUTWASH (OW): Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL): Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB): These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD): These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In Ontario, such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present.

GLACIOLACUSTRINE PLAINS (LP): The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM): These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN FORMS (WD): Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consists of fine to coarse sand and are usually well sorted. The probabiltiy of locating crushable aggregate in windblown deposits is very low.

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